CLAIMS

1. A process for forming diffusion aluminide coatings on an uncoated surface of a substrate, without interdiffusing a sufficient amount of aluminum into a coating layer to adversely affect the coating growth potential or mechanical properties of said coating layer, comprising the steps of:

   providing a metal substrate comprising an external surface and an internal passage therein defined by an internal surface, at least a portion of the external surface of the substrate being coated with a coating layer selected from the group consisting of β-NiAl-base, MCrAlX, a line-of sight diffusion aluminide, a non-line-of-sight diffusion aluminide, a pack diffusion aluminide, and a slurry diffusion aluminide on said substrate;

   cleaning the external surface of the substrate;

   subjecting the metal substrate to a aluminum vapor phase deposition process performed using a fluorine-containing activator selected from the group consisting of AlF_3, CrF_3, NH_4F, and combinations thereof, at a rate in the range of about 0.036 mols of fluorine per ft^3/hr of transport gas to about 0.18 mols of fluorine per ft^3/hr of transport gas, at a temperature in the range of about 1350°F to about 1925°F, using a transport gas selected from the group consisting of argon, nitrogen, hydrogen, and combinations thereof, the transport gas being provided at a flow rate in the range of about 20 ft^3/hr to about 120 ft^3/hr for a period of time in the range of about 2 hours to about 10 hours; and

   cooling the substrate.

2. The process of claim 1, wherein the coating layer is a β-NiAl-base layer.

3. The process of claim 2, wherein the coating layer is a β-NiAlCrZr layer.

4. The process of claim 3, wherein the β-NiAlCrZr coating layer comprises about 53.5 weight percent nickel to about 64.5 weight percent nickel, about 20 weight to about

30 weight percent aluminum, about 2 weight percent to about 15 weight percent chromium, and about 0.5 weight percent to about 1.5 weight percent zirconium.

5. The process of claim 4, wherein the β-NiAlCrZr coating layer comprises about 60 weight percent nickel, about 27 weight percent aluminum, about 12 weight percent chromium, and about 1 weight percent zirconium.

6. The process of claim 1, wherein the coating layer is a non-line-of-sight diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.

7. The process of claim 1, wherein the coating is a pack diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.

8. The process of claim 1, wherein the coating is a slurry diffusion aluminide layer comprising aluminum, chromium, and a material selected from the group consisting of a reactive element, a noble metal, and combinations thereof.

9. The process of claim 1, wherein the coating layer is MCrAlX, where M is a metal selected from the group consisting of iron, cobalt, nickel, and combinations thereof.

10. The process of claim 1 further comprising the additional step of densifying and smoothing the coating layer using a shot peen treatment prior to the step of cleaning the external surface of the substrate.

11. The process of claim 1 further comprising the additional step of masking a preselected external portion of the substrate prior to the step of subjecting the metal substrate to an aluminum vapor phase deposition process.

12. The process of claim 1 further comprising the additional step of subjecting the coating layer to a surface finish treatment to reduce the roughness of the coating layer.

13. The process of claim 1 further comprising the additional step of applying a thermal bond coat to the coating layer.

14. The process of claim 12 further comprising the additional step of applying a thermal bond coat to the coating layer.

15. The process of claim 1, wherein the aluminum vapor phase deposition process is performed using an AlF_3 activator at a rate of 0.036 mols of fluorine per ft^3/hr of transport gas, at a temperature of about 1900°F, the transport gas being provided at a flow rate of about 20 ft^3/hr for a period of time of about 6 hours.

16. The process of claim 4, wherein the aluminum vapor phase deposition process is performed using an AlF_3 activator at a rate of 0.036 mols of fluorine per ft^3/hr of transport gas, at a temperature of about 1900°F, the transport gas being provided at a flow rate of about 20 ft^3/hr for a period of time of about 6 hours.

17. The process of claim 5, wherein the aluminum vapor phase deposition process is performed using an AlF_3 activator at a rate of 0.036 mols of fluorine per ft^3/hr of transport gas, at a temperature of about 1900°F, the transport gas being provided at a flow rate of about 20 ft^3/hr for a period of time of about 6 hours.

18. A superalloy article comprising:

a substrate, comprising an external surface and an internal passage therein defined by a internal surface, both the internal surface and the external surface having been low in aluminum content immediately after initial manufacture of the superalloy article;

a first aluminum-rich layer being present on the external surface, the first aluminum-rich layer having been applied to the external surface after initial manufacture, the first aluminum-rich layer making the external surface aluminum-rich and forming an aluminum-rich surface on the external surface, with the internal surface remaining low in aluminum content after the application of the aluminum-rich layer to the external surface; and

a second aluminum-rich layer being present on the internal surface, the second aluminum-rich layer having been applied to the external surface after the application of the first aluminum-rich layer, the second aluminum-rich

layer having been applied by exposing both the external surface and the internal surface to an aluminum-rich atmosphere, such exposure depositing aluminum onto and diffusing aluminum into the internal surface without the already aluminum-rich first external surface undergoing a phase change and without depositing sufficient aluminum onto and sufficient aluminum into the external surface to adversely affect the coating growth potential and mechanical properties of the first aluminum-rich layer.

19. The superalloy article of claim 18, wherein the superalloy article is a turbine blade.

20. A superalloy article coated with a diffusion aluminide layer using the process of claim 1.

21. A an turbine engine component comprising:

a superalloy substrate, comprising a surface, the surface having been low in aluminum content immediately after initial manufacture of the superalloy article;

a first aluminum-rich layer being present on a first portion of the surface, the first aluminum-rich layer having been applied to the first portion of the surface after initial manufacture, the first aluminum-rich layer making the first portion of the surface aluminum-rich and forming an aluminum-rich surface on the first portion of the surface, with a second portion of the surface remaining low in aluminum content after the application of the aluminum-rich layer to the first portion of the surface; and

a second aluminum-rich layer being present on a second portion of the surface, the second aluminum-rich layer having been applied to the second portion of the surface after the application of the first aluminum-rich layer, the second aluminum-rich layer having been applied by exposing both the first portion of the surface and the second portion of the surface to an aluminum-rich atmosphere, such exposure depositing aluminum onto and diffusing aluminum into the second portion of the surface without the already aluminum-rich first portion of the surface undergoing a phase change and

without depositing sufficient aluminum onto and sufficient aluminum into the first portion of the surface to adversely affect the coating growth potential and mechanical properties of the first aluminum-rich layer.

22. The turbine engine component of claim 21, wherein the component is a turbine vane.

23. The turbine engine component of claim 21, wherein the component is a deflector.

24. The turbine engine component of claim 21, wherein the component is a centerbody.

25. The turbine engine component of claim 21, wherein the component is a splash plate.

26. The turbine engine component of claim 21, wherein the component is a shroud.

27. The turbine engine component of claim 21, wherein the component is a turbine blade.